Echo Lake Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2012 at Echo Lake

King County Lake Stewardship Program

Prepared for the City of Shoreline
by the King County Lakes and Streams Monitoring Group
Science and Technical Support Section,
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King County

CITY OF SHORELINE

Overview

The King County Lakes and Streams Monitoring unit (KCLSM) and its predecessor the Lake Stewardship Program began working with volunteer monitors to monitor Echo Lake in 2001. The lake was not monitored in 2002, but work resumed in 2003 and has continued to the present. In 2005, City of Shoreline staff members began sampling the lake according to the protocols and schedule of the volunteer monitoring program run through the program.

The City of Shoreline participates in the Level II monitoring that takes 12 samples between the months of May and October. The data collected include water temperature, Secchi depth and a suite of water chemistry parameters. The water quality data indicate that currently the lake is moderately high in primary productivity with fair water quality.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson, 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae that could be produced in the lake. A second measure is the nitrogen to phosphorus ratio (N:P), which is used to predict what groups of algae may become dominant in the lake during certain periods. Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The City has also participated in a four year cyanobacteria monitoring project called the Regional Examination of Harmful Algal Blooms (REHAB). The end of this report summarizes the 2012 efforts at this lake.

The discussion in this report focuses on the 2012 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lakes and Streams Monitoring data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

The data and associated charts can be provided in the form of excel files upon request.

Physical Parameters

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

For Echo Lake, Secchi transparency values collected from May through October ranged from 1.1 m to 5.0 m, averaging 2.3 m (Figure 1). Note that the Y-axis is traditionally reversed on Secchi charts from the usual direction of increase to mimic looking into the water.

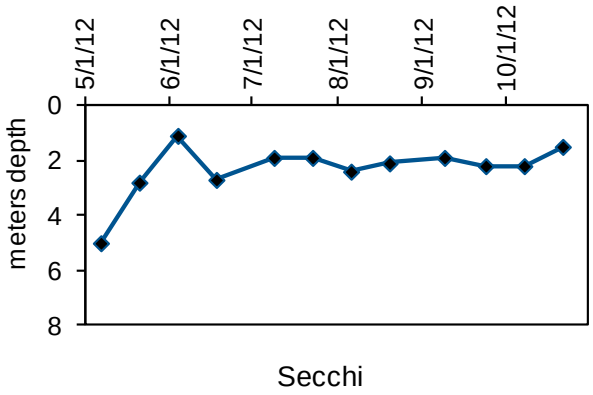

Figure 1. Echo Lake Secchi Transparency

Compared to data collected in previous years, the Secchi transparency values exhibited similar variability through the season. The values coincides with the high and low chlorophyll-a values (see later in this report), indicating that the declining transparency in June was due to the onset of an algae bloom. After the algae bloom subsided, the Secchi levels leveled off for the rest of the season although clarity remained lower than the spring readings, suggesting algae remained abundant in the lake throughout the sampling season.

Water temperatures during the sampling period generally followed a pattern similar to other lakes in the region. Temperatures were cooler in the spring, followed by summer maximum temperatures occurring between mid-July and mid-August, and then temperatures cooling slowly in the fall (Figure 2). Echo Lake water temperature at 1 m depth ranged from 12.7 degrees Celsius to 23.5 degrees Celsius with an average of 18.2. Compared to other lakes monitored through KCLSM in 2012, Echo Lake is in the lower third in terms of summer temperature maxima.

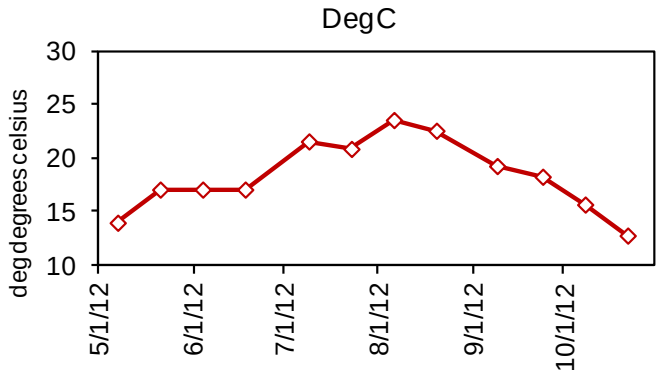

Figure 2. Echo Lake Water Temperatures

The 2012 peak temperature was slightly warmer than the 2011 water year but not as warm as 2009 (Figure 3). Summer in 2009 was warmer and sunnier than normal, and Echo had a peak temperature of 26.3 degrees Celsius in that year. Strong La Nina events occurred in 2010 and 2011, which caused cooler temperatures throughout the region. The 2012 water year temperatures were warmer than the previous two years. No trend in temperature over time can be detected from this record, but further monitoring will help determine if summer temperatures in Echo Lake are warming up or remaining stable.

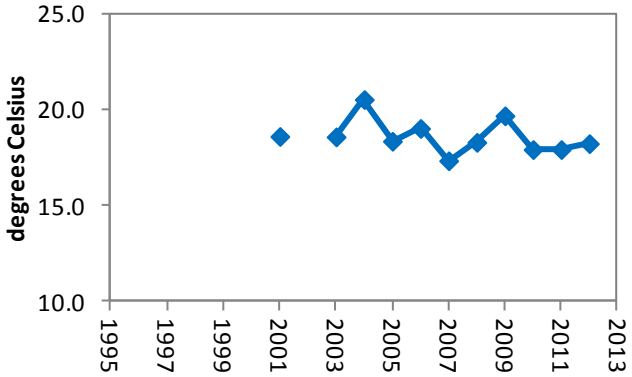

Figure 3: Echo Lake average water temperature for May-October.

Nutrient and Chlorophyll Analysis

Phosphorus and **nitrogen** are naturally occurring elements that are necessary in small amounts for both plants and animals for healthy growth and reproduction. However, many actions associated with residential and commercial development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in

phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth, between May and October, with deeper water analyzed twice through the season, May and August respectively.

The 1m TP and TN increased through May and into early June. A huge spike in TN occurred in the early June sample but it wasn't mirrored in the TP sample (Figure 4). It was documented through the REHAB project that a large bloom of bluegreen algae (cyanobacteria) was present in early June, concurrent with the TN spike. Many bluegreen species are nitrogen fixers, so while they need phosphorus from the water to grow, they can pull nitrogen from the air and may be able to fix more than they subsequently use (luxury uptake). The peak in nitrogen is concurrent with a peak in chlorophyll *a* discussed below.

The nutrients decreased after that early spring spike and maintained consistent levels for the rest of the season. The last sampling date in October showed that phosphorus was on the rise and could explain the onset of the late season cyanobacteria blooms in the lake (discussed in a later sections).

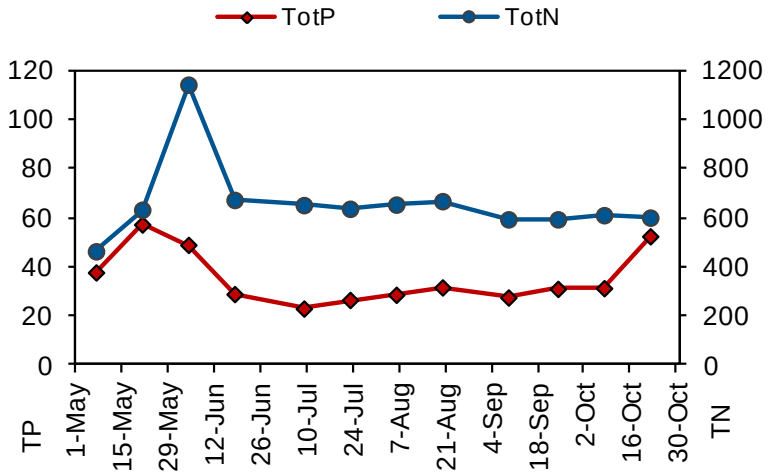

Figure 4. Echo Lake Nutrients in ug/L.

The ratio of TN to phosphorus TP can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria that can impact beneficial uses of the lake. When N:P ratios are near or below 20-25, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air.

In 2012, the N:P ratio at Echo Lake ranged from 11.1 to 28.4 with an average of 19.8, which indicated that the nutrient conditions in the lake were favorable for bluegreen algae blooms for the majority of the sample period (Figure 5). In particular, the early spring and fall had optimal nutrient conditions for bluegreen blooms, very similar to previous years. As discussed later in the report, Echo Lake supported a large *Aphanizomenon* bloom in spring and then a *Microcystis* bloom in late fall that did become toxic.

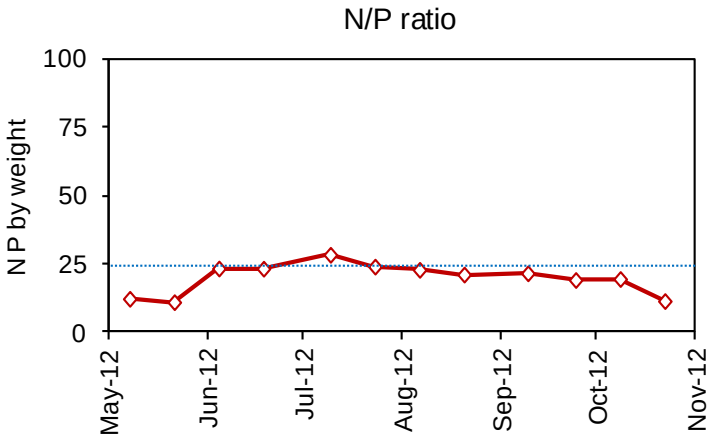

Figure 5: Echo Lake N:P ratios during the sampling season. Values below the blue **line indicate a potential nutrient advantage for cyanobacteria.**

Chlorophyll *a* values in 2012 peaked in early June (Figure 6), which coincided with the spike in total nitrogen and likely represents a cyanobacterial bloom because many of these organisms can fix nitrogen from the air. Values dropped at the beginning of summer, but increased steadily as the season progressed and began to drop again September. Pheophytin, a degradation product of chlorophyll, remained at low levels most of the season, except for an increase during early June, when the spike in chlorophyll occurred.

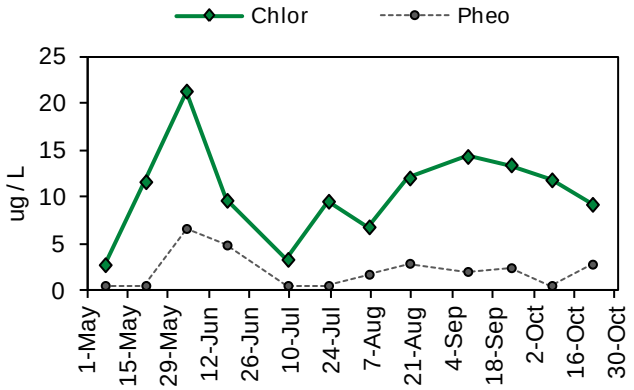

Figure 6. Echo Lake Chlorophyll *a* and Pheophytin Concentrations

Water column profiles

Profile temperature data indicate that thermal stratification was present early in the season and persisted through the summer (Table 1). For both May and August sampling events, the deep (7 m) meter samples had elevated concentrations of phosphorus and orthophosphate, although the August measurements in the deep water were quite a bit higher than that in late May. Ammonia (NH3) concentrations were also high in the deep water, indicating that anoxic conditions contributed to the elevated nutrient levels via sediment release.

Chlorophyll data suggest that in the early part of the sampling season most algae were in the upper portion of the water column, but in late summer more were to be found in the deeper portion of the water column, possibly taking up phosphorus released from the sediments.

Table 1. 2012 Echo Lake profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Echo-Shore	5/21/12	2.8	1	17.0	11.60	**0.5**	0.631	**0.005**	0.0571	0.0024	0.0899	17.8
Echo-Shore			3	17.0	10.00	1.1	0.553		0.0481			
Echo-Shore			7	8.0	1.61	1.8	0.579	0.141	0.073	0.0535		
Echo-Shore	8/20/12	2.1	1	22.5	12.0	2.87	0.666	**0.005**	0.0315	**0.002**	0.067	17.6
Echo-Shore			3	21.5	12.9	2.95	0.689		0.0412			
Echo-Shore			7	9.0	54.6		1.280	0.678	0.4560	0.166		

The relatively low values for UV254 indicate that the water of the lake is clear, with little coloration from organic substances, while the total alkalinity values show that the water in the lake is soft, with little buffering capacity against pH change.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating values for the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of a lake based on water clarity (Secchi transparency), as well as concentrations of total phosphorus and chlorophyll *a*. The Index relates to three categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

For Echo Lake, the three indicators from 2001 through 2012 do not show any solid trends towards change over time (Figure 7). The levels in 2012 show an increase over the 2011 values, but are still lower than the 2010 values. Over the years, the Secchi TSI generally predicted lower algal biovolumes than the other two parameters, which may be due to the clumping or particulate nature of the cyanobacterial species that dominated the phytoplankton. Algae making relatively larger particles do not impact water clarity as much as small algae that produce cloudiness when abundant.

Combining the TSI values suggests that Echo Lake is in the lower end of the eutrophic category, with a value of 52.0. This is the second highest level recorded for this lake, as 2004 was the highest with a TSI of 53.3.

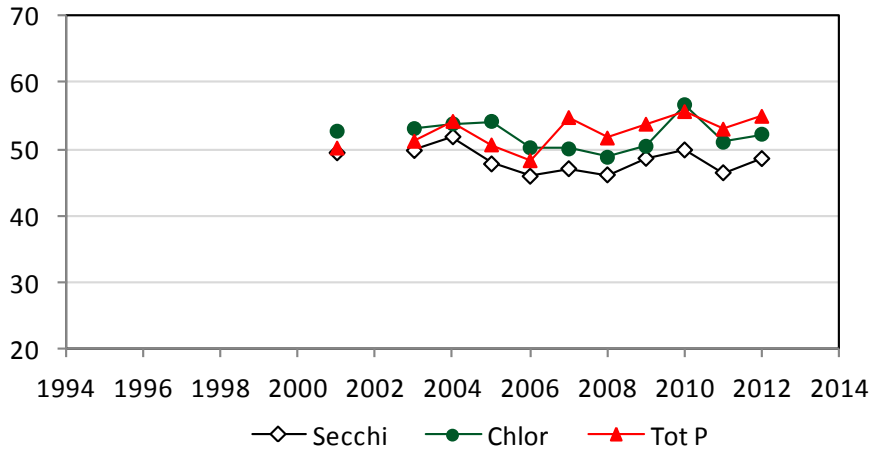

Figure 7. TSI Values at Echo Lake

Cyanobacteria toxins

Because of its history of occasionally producing bluegreen (cyanobacteria) blooms, Echo Lake was chosen as one of 30 Puget lowland lakes to be studied as part of work funded by a grant from the Federal Center for Disease Control (CDC) to the Washington Department of Health, working in collaboration with King, Snohomish, and Pierce Counties. The study involved regular biweekly sampling at a selected site for bluegreen species abundance and toxicity between June and October for three consecutive years between 2009 and 2011, and nine of the lakes were chosen for study in 2012 because of their performance during the first 3 years. Four algal toxins were measured in 2012: microcystin, anatoxin-a, saxitoxin and cylindrospermopsin.

In Echo Lake, the routine site chosen for monitoring was at the public park because that is where most people and pets come in contact with the water. The first sample of the season in June had very small values of both microcystin and anatoxin-a (Table 2). This was concurrent with the intense *Aphanizomenon* bloom that occurred in early summer. However, all toxins remained at low levels below the provisional state guidelines for the remaining nine sampling events. No detectable amounts of saxitoxin or cylindrospermopsin toxins were found.

Aside from the routine samples, bloom samples were submitted under the Washington Department of Ecology Freshwater Algae Monitoring Program. Compared to 2011, more blooms were submitted in 2012, with bloom activity increasing in fall. In early September a large bloom occurred with a microcystin value of 42.0 ug/L, which is well above the 6 ug/L recreational guideline. The City took action and posted warning signs at the lake until the bloom dissipated and fell below recreational guidelines. Even with the bloom dissipating, a Caution sign remained up at the park for the rest of September and October. In early November, another bloom began, and while toxin levels were less than the September bloom, it peaked at 8.73 ug/L. This bloom dropped off quickly and by the end of November all postings on the Lake were removed.

Table 2: REHAB routine monitoring results for cyanobacteria toxins. When the reported value equals the MDL the toxin was below detection levels.

ROUTINE										
Sample ID	Collect Date	Client Locator	Anatoxin-a VALUE (ug/L)	Anatoxin-a MDL (ug/L)	Cylindrospermopsin VALUE (ug/L)	Cylindrospermopsin MDL (ug/L)	Microcystin VALUE (ug/L)	Microcystin MDL (ug/L)	Saxitoxin VALUE (ug/L)	Saxitoxin MDL (ug/L)
L55742-11	4-Jun-12	Echo	0.0257	0.0185	0.1	0.1	0.0675	0.05	0.02	0.02
L55744-11	18-Jun-12	Echo	0.0297	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L55745-11	9-Jul-12	Echo	0.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L55888-11	23-Jul-12	Echo	0.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L55917-11	6-Aug-12	Echo	0.0185	0.0185	0.1	0.1	0.445	0.05	0.02	0.02
L56118-11	20-Aug-12	Echo	0.0185	0.0185	0.1	0.1	2.5	0.05	0.02	0.02
L56203-11	10-Sep-12	Echo	0.0185	0.0185	0.1	0.1	0.43	0.05	0.02	0.02
L56295-11	24-Sep-12	Echo	0.0185	0.0185	0.1	0.1	0.668	0.05	0.02	0.02
L56461-11	8-Oct-12	Echo	0.0185	0.0185	0.1	0.1	0.352	0.05	0.02	0.02
L56526-11	22-Oct-12	Echo	0.0185	0.0185	0.1	0.1	0.0795	0.05	0.02	0.02

BLOOMS										
Sample ID	Collect Date	Client Locator	Anatoxin-a VALUE (ug/L)	Anatoxin-a MDL (ug/L)	Cylindrospermopsin VALUE (ug/L)	Cylindrospermopsin MDL (ug/L)	Microcystin VALUE (ug/L)	Microcystin MDL (ug/L)	Saxitoxin VALUE (ug/L)	Saxitoxin MDL (ug/L)
L56524-1	9/14/2012	Echo	0.0185	0.0185	-	-	**42.0**	0.05	-	-
L56562-1	9/24/2012	Echo	0.0185	0.0185	0.1	0.1	5.61	0.05	0.02	0.02
L56657-1	10/2/2012	Echo	0.0185	0.0185	-	-	4.26	0.05	-	-
L56708-1	10/8/2012	Echo	-	-	-	-	1.41	0.05	-	-
L56931-1	11/2/2012	Echo	-	-	-	-	**8.73**	0.05	-	-
L56982-1	11/13/2012	Echo	0.027	-	0.1	0.1	1.03	0.05	0.02	0.02

Conclusions and Recommendations

Based on the monitoring data, water quality in Echo Lake appears to have been relatively stable over the period measured, although there might be a trend towards increasing eutrophication. It is encouraged that routine monitoring continues to see if the increases are due to yearly variability or signs of a trend towards increasing productivity.

Low N:P ratios throughout most of the monitoring period in 2012 indicated nutrient conditions were favorable for nuisance bluegreen algae blooms. Routine toxicity testing at the beach through the REHAB project produced low levels of toxicity. However, more blooms occurred this year and the fall blooms produced toxicity levels above the recreational guidelines. During the blooms in fall the weather was still quite warm, and the lake was still a recreational destination for both citizens and their pets. Careful monitoring of algae blooms at the lake in the spring and fall should continue to ensure that signage is posted to inform people of the risks as soon as. When blooms occur, the Washington State Ecology Freshwater Algae Monitoring Program offers free testing through the King County Environmental Lab. In conjunction with the Ecology program, Echo Lake would benefit from routine surveillance set up during the same time period as the water quality monitoring project. This will allow the city to test and detect toxins as soon as a large bloom occurs in the lake, and posting could occur earlier, thus reducing the risk of public health problems.